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RDTs 6500-006

FINAL REPORT

ECOLOGY OF TOWNSEND GROUND SQUIRRELS IN THE BIRDS OF PREY STUDY AREA

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In partial fulfillment of the requirements of
USDI, Bureau of Land Management
Contract 52500-CT5-1002

1 November 1974 through 1 November 1978

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Daniel L. Sedlock, Contracting Officer
USDI, Bureau of Land Management
Denver Federal Center
Denver, Colorado 80225

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and

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SUMMARY

The structure and regulation of the Townsend ground squirrel (*Spermophilus townsendi*) population inhabiting the Birds of Prey Study Area (BPSA) in southwestern Idaho was investigated during a four-year study. Squirrels were live-trapped, marked and released at six sites representative of the major habitat types found in the region. Densities varied between sites and years from 1 to 20 squirrels per hectare (ha). Range fires and grazing promote the growth of annual grasses, the primary dietary component of squirrels. Hence range fires and grazing on sites which produce healthy stands of annual grasses indirectly favor an increase in squirrel density.

Sex ratios, litter size, pregnancy rates, survival and recruitment are reported for age classes within the squirrel population. Reproduction was suspended during the 1977 drought, reducing density by about one-half. In 1978, the population increased as a result of increases in survival, immigration and litter size.

The squirrel population received considerable predation pressure from western rattlesnakes (*Crotalus viridis*), badgers (*Taxidea taxus*) and several species of raptors, but the density and distribution of ground squirrels is more readily affected by the availability of green forage and ultimately by the pattern of precipitation than by the effects of predation.

Bubonic plague persists at chronic levels in rodent and badger populations on the BPSA. The potential exists for plague decimation of the squirrel population.

INTRODUCTION

1

Townsend ground squirrels are the primary prey of prairie falcons (*Falco mexicanus*), red-tailed hawks (*Buteo jamaicensis*) and ravens (*Corvus corax*) that nest on the Birds of Prey Study Area in southwestern Idaho (Ogden and Hornocker 1977; Kochert et al. 1976). Badgers, which occur in large numbers on the BPSA and western rattlesnakes also prey heavily on Townsend ground squirrels (Hornocker et al. 1976; Johnson and Diller 1976). Recognizing the importance of the Townsend ground squirrel in this ecosystem, the Bureau of Land Management (BLM) contracted a four-year study of ground squirrel ecology on the BPSA with the objectives of:

1. Describing the population variables including productivity, recruitment, age and sex ratios and turnover rates.
2. Ascertaining population density (a) within representative habitat types, (b) in relation to land use patterns including the effects of cultivation on density, and, (c) in hunting areas of those raptors outlined by the radio-telemetry study (Study III).
3. Ascertaining food habits and habitat requirements in the major vegetation types.
4. Isolating factors (predation, disease, parasites, etc.) which may limit ground squirrel density and distribution.

We summarize the results of this study here.

ACKNOWLEDGEMENTS

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We thank M. N. Kochert of the Bureau of Land Management for continued encouragement throughout this study. Karen Steenhof, Bureau of Land Management, provided editorial assistance in preparing this report. We received field assistance during the course of this study from Randall Olson, E. Martin Cobb, C. E. Woodley and Victoria Saab. Tom Dunstan, Steve Peterson and Gayle Sitter assisted us in many ways. Maurice Hornocker and John Messick worked closely with us on the plague study. Lastly, we extend our sincere appreciation to Wayne Melquist, research associate on this study in 1975, who provided us with a solid beginning.

This work was funded under the USDI Bureau of Land Management Contract No. 52550-CT5-1002 to the University of Idaho.

STUDY AREA

The steppe vegetation of the Snake River plain consists of broad stretches of shrubs and associated forbs and grasses. The major shrub dominants are big sage (*Artemisia tridentata*), winterfat (*Cercocarpus lanata*), shadscale (*Atriplex confertifolia*) and greasewood (*Sarcobatus vermiculatus*). Six study sites were located in major vegetation types on the BPSA in 1975 and 1976 (Fig. 1). Each site consisted of a grid pattern of stakes set out at 10 m intervals over 1 ha.

Site 1 (Section 6, Township 2 South, Range 1 East, Boise Meridian) once supported a stand of winterfat which has been depleted by sheep. The site now supports weedy annuals, primarily cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*) (Table 1).

Site 2 (S 7, T 2 S, R 1 E), located in the same habitat type, was also grazed by sheep although less heavily than at Site 1. Sandberg bluegrass (*Poa sandbergii*) was the principal grass present (Table 1).

Site 3 (S 17, T 2 S, R 1 E) was located within the perimeter of a range burn which destroyed the shrub cover at this location on 24 June 1974. Russian thistle and cheatgrass now comprise most of the ground cover at this location (Table 1).

Site 4 (S 17, T 2 S, R 1 E) represented the same habitat type undisturbed by fire. Winterfat, big sage and hop sage (*Atriplex spinosa*) were the principal shrubs present (Table 1).

Site 5 (S 30, T 1 S, R 1 E) was established in a grazed big sage-Sandberg bluegrass habitat. Horsebrush (*Tetradymia glabrata*) was also present (Table 1).

Site 6 (S 36, T 4 S, R 3 E) was located in a shadscale and bud sage (*Artemisia spinescens*) stand. Few grasses were present (Table 1).

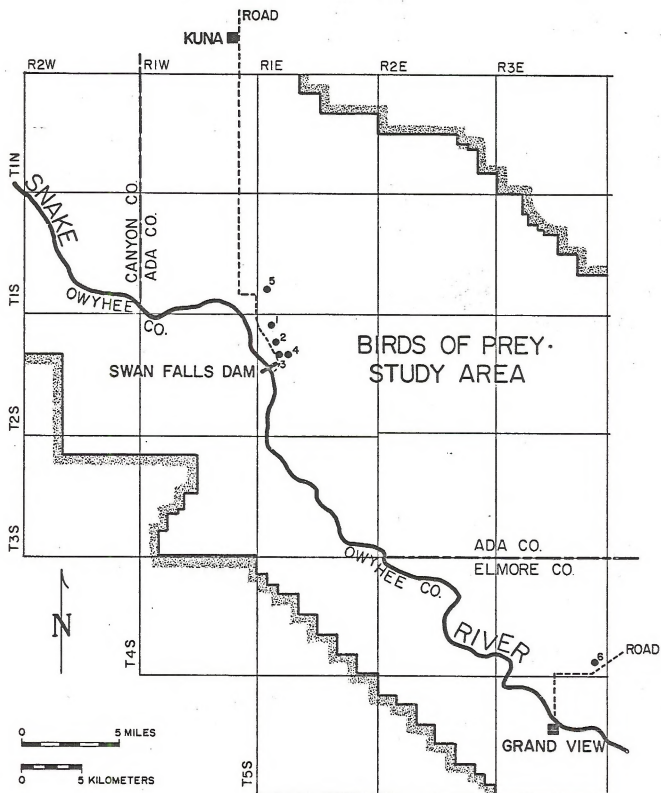


Fig. 1. Location of intensive study sites in the Snake River Birds of Prey Study Area.

Table 1. Plant coverage (%) on intensive study sites 1 through 4, 1975-78.

	Site 1				Site 2			
	1975	1976	1977	1978	1975	1976	1977	1978
Shrubs								
<i>Cerratooides lanata</i>	<1	1.3	1.0	1.0	14.5	12.2	7.3	26.1
Forbs								
Cruciferae	2.0	<1	--	16.1	<1	<1	--	2.0
<i>Salsola kali</i>	--	--	--	31.5	--	--	--	--
Grasses								
<i>Bromus tectorum</i>	60.2	66.3	<1	15.1	1.5	<1	--	--
<i>Poa sandbergii</i>	4.6	1.7	<1	1.0	3.2	4.0	2.0	1.7
<i>Festuca octoflora</i>	--	--	--	--	20.3	7.4	<1	6.4
Bare Ground	35.2	30.0	98.4	35.3	61.1	76.2	90.7	63.8
	Site 3				Site 4			
	1975	1976	1977	1978	1975	1976	1977	1978
Shrubs								
<i>Cerratooides lanata</i>	<1	<1	<1	<1	9.8	8.5	6.2	16.0
<i>Artemisia tridentata</i>	--	--	--	--	5.4	4.3	4.2	4.7
<i>Atriplex spinosa</i>	--	--	--	--	2.8	1.1	<1	1.1
Forbs								
Cruciferae	<1	--	--	<1	1.1	<1	--	--
<i>Salsola kali</i>	--	--	--	14.8	--	--	--	<1
Grasses								
<i>Bromus tectorum</i>	4.0	6.1	--	2.7	<1	<1	--	--
<i>Poa sandbergii</i>	5.8	8.9	<1	3.2	3.4	4.4	<1	<1
<i>Sitanion hystrix</i>	--	--	--	1.0	--	--	--	--
Bare Ground	89.4	84.5	98.7	77.3	79.8	82.5	89.1	77.2

Table 1 (Continued). Plant coverage (%) on intensive study sites 5 and 6, 1976-78.

	Site 5			Site 6	
	1976	1977	1978	1976	1977
Shrubs					
<i>Artemisia tridentata</i>	4.1	8.7	10.9	--	1.0
<i>Artemisia spinescens</i>	--	--	--	2.5	2.1
<i>Atriplex confertifolia</i>	--	--	--	3.5	6.9
<i>Tetradymia glabrata</i>	--	--	--	1.4	1.7
Forbs					
Cruciferae	--	--	20.4	--	--
<i>Salsola kali</i>	--	--	3.9	--	--
Grasses					
<i>Bromus tectorum</i>	22.0	<1	8.9	2.0	--
<i>Poa sandbergii</i>	7.1	<1	1.5	--	--
<i>Elymus condensatus</i>	--	--	1.0	--	--
Bare Ground	67.0	89.3	53.4	95.0	88.3

METHODS

Study sites were trapped twice weekly from early February to mid-June using a minimum of 20 live traps (10 x 10 x 40 cm) fabricated by W. H. Grieser, Conneaut Lake, PA. Traps were set in the morning and checked periodically throughout the day. There was little trap mortality. Apple was used as bait. Trapped squirrels were anesthetized with diethyl ether and permanently marked by tow clipping. The capture location, body weight and reproductive condition (testes position and nipple visibility) were recorded.

Juveniles (young of the year) were readily distinguished by their size and weight. Yearling males were separated from older age classes by body weight and testes position. (Most yearling males possessed abdominal testes throughout the breeding season). Yearling females were distinguished from older age classes by body weight and reproductive state (some yearling females did not breed).

These criteria were not effective in identifying yearling males if they were first captured after the breeding season when all males possessed abdominal testes and body weights of the yearlings were comparable to that of older age groups. Nor were we able to identify yearling females with certainty if they were caught the first time late in pregnancy. Fifty six squirrels, 21 males and 35 females, could not be assigned to specific age groups because of these difficulties.

Density estimates were based on recapture frequency. We were faced with the difficulties of working with an open population (one subject to immigration and emigration) which was composed of individuals of unequal catchability. Eberhardt (1969) has shown that density estimators based on the geometric distribution provide a good fit of

recapture data collected in several wildlife studies, including those involving open populations. The advantage of using these models is that they circumvent the problem of unequal catchability by estimating the number of animals in the zero class (those not caught). Overton (1971) suggested that the good fit provided by these estimators may be fortuitous. He proposed the use of a non-parametric estimator. We have used both Eberhardt and Overton estimators in calculating density of the squirrel population on the intensive study sites.

Density indices elsewhere on the BPSA were derived by converting ground squirrel hole counts to density estimates. Ground squirrel hole counts were made on 373 systematically selected transects (Steel and Torrie 1960) in 1977 and 1978. Each transect was 0.2 ha (10 x 200 m) in area. The location of these sites is reported in Appendix A. Conversion factors for each vegetation type were derived by comparing density estimates for the intensive study sites as described above with ground squirrel hole counts on transects through each intensive site.

We also attempted to relate ground squirrel density to soil characteristics. Since soils information was available for only the western part of the BPSA (Ada County), we were not able to investigate this relationship in depth.

On intensive study sites, we estimated plant coverage on 0.25 m^2 circular plots (66 at each site) yearly in late May, the peak of the growing season for annual grasses. Coverage of each species was visualized as a polygon enclosing the extremities of the canopy of each plant (Daubenmire 1959). Area covered by mosses, litter and rocks was

included in the bare ground estimate. Taxa which averaged less than 1% at a site were ignored. Total coverage sometimes exceeded 100% because of stratification.

Squirrels were collected off the study sites using a .22 caliber rifle. Reproductive tracts of females were examined for visible embryos and placental scars. The stomachs were removed and their contents examined using the techniques of Johnson and Groepper (1970).

Counts of fresh badger digs on study sites were recorded monthly. Multiple holes dug at the same location were counted as a single hunting attempt.

Blood samples were collected periodically from badgers by personnel of Study IV-B as a means of monitoring the incidence and exposure to the plague organism *Yersinia pestis*. These blood samples together with spleens and livers of moribund and dead squirrels found on the study area were analyzed for bubonic plague by personnel of the Center for Disease Control, U. S. Public Health Service, Fort Collins, Colorado.

The data collected throughout this study were subjected to appropriate statistical tests (Nie et al. 1975) using BLM computer facilities. We used the 5% level of significance for all tests.

RESULTS AND DISCUSSION

Population Structure

One thousand and fifty three squirrels were captured during this study of which 517 (49%) were males and 536 (51%) were females. Of these, 512 (49%) were juveniles (young of the year), 222 (21%) were yearlings, 262 (25%) were adults two or more years of age and 56 (5%) were squirrels of uncertain age (at least one year old). A summary of all captures appears in Appendix B.

Unmarked squirrels appearing in a marked population after the first year of trapping were either (1) trap-shy residents caught for the first time, (2) immigrants, or, (3) transients. Transients can be identified as unmarked squirrels caught only once. Unmarked squirrels recaptured in subsequent years are either trap-shy residents or immigrants (squirrels establishing residence on the site). We have no sure way of distinguishing these classes. Squirrels which were either trap-shy residents or immigrants comprised 14% of the male population and 9% of the female population during 1976 and 1977. If these are added to the number of known residents, the total overestimates the true resident population since immigrants are ignored; if these squirrels are added to the number identified as transients, the occurrence of trap-shy residents is ignored.

In describing the structure of the squirrel population (Table 2), we have reported both values recognizing that one overestimates and the other underestimates the number of squirrels in each category. Since residents are only identified after recapture the following year, we are unable to describe the population structure for 1975 and 1978.

Residents comprised 45-58% and transients 42-55% of the male

Table 2. Population structure, 1976 and 1977. Percent in parentheses.

* Significant difference between sexes; ** significant difference between years.

ASSUMING NO IMMIGRATION										
Sex	Year	N	Y	Residents			Y	Transients		
				A	U	Total		A	U	Total
Male	1976	55	14	20	2	36 (65)	10	6	3	19 (35)
	1977	77	23	18	0	41 (53)	17	12	7	36 (47)
	Total	132	37	38	2	77 (58)	27	18	10	55 (42)
Female	1976	82	22	31	2	55 (67)	12	3	12	27 (33)
	1977	78	31	27	6	64 (82)**	8	0	6	14 (18)**
	Total	160	51	58	8	119 (74)*	20	3	18	41 (26)*
ASSUMING NO TRAP-SHY RESIDENTS										
Male	1976	55	9	19	0	28 (51)	15	7	5	27 (49)
	1977	77	16	15	0	31 (40)	24	15	7	46 (60)
	Total	132	25	34	0	59 (45)	39	22	12	73 (55)
Female	1976	82	22	29	0	51 (62)	12	5	14	31 (38)
	1977	78	29	25	0	54 (69)	10	2	12	24 (31)
	Total	160	51	54	0	105 (66)*	22	7	26	55 (34)*

N = sample size

Y = yearling

A = adult

U = uncertain age

population in 1976 and 1977 (Table 2). Residents represented 66-74% and transients 26-34% of the female population during the same period. The differences between the sexes with respect to the proportion of residents and transients are significant ($Z = 2.93$ assuming no immigration; $Z = 3.6$ assuming no trap-shy residents). We conclude that males are more mobile than females, a finding confirmed for other species of ground squirrels (Fitch 1948; Michener and Michener 1977; Dorrance 1974).

Survival

The difficulty in indentifying squirrels as residents, immigrants or transients also affects the calculation of survival (Table 3). Again, the problem results from our inability to distinguish immigrants from trap-shy residents. If survival estimates are based on the number of marked squirrels captured the following year, its true value is underestimated since some squirrels successfully emigrate. If all unmarked squirrels caught for the first time are identified as immigrants, the occurrence of trap-shy residents is ignored and survival is overestimated. We have chosen the conservative approach, reporting survival based solely on recapture of marked squirrels the following year (Table 3).

The survival of juvenile males was significantly less (minimum Z value 2.74) than that of all other classes. We attribute this to dispersal of juvenile males from their place of birth and perhaps to greater mortality of juvenile males locally. Michener and Michener (1973, 1977) found that juvenile males of the Richardson ground squirrel (*Spermophilus richardsoni*) were more likely to disperse than juvenile females.

There was also a significant decrease ($Z = 3.73$) in the survival of

Table 3. Overwinter survival. Percent in parentheses. -- No juvenile cohort. * Significant difference between sexes; ** significant difference between years.

Age Group/Sex	1975-76	1976-77	1977-78	All Years
Juvenile				
Male	9/63 (14)	16/155 (10)	--	25/218 (11)
Female	22/43 (51)	30/138 (22)**	--	52/181 (29)*
Total	31/106 (29)	46/293 (17)**	--	77/399 (19)
Yearling				
Male	9/30 (30)	8/24 (33)	8/36 (22)	17/54 (31)
Female	16/47 (34)	7/36 (19)	12/38 (32)	35/121 (29)
Total	25/77 (32)	15/60 (25)	20/74 (27)	52/175 (30)
Adult				
Male	5/24 (21)	6/29 (21)	9/30 (30)	20/83 (24)
Female	8/28 (29)	11/38 (29)	13/27 (48)	32/93 (34)
Total	13/52 (25)	17/67 (25)	22/57 (39)	52/176 (30)
All Ages	69/235 (29)	78/420 (19)**	42/131 (32)**	189/786 (24)

juvenile females in 1976-1977 from that of the previous year (Table 3). The survival of yearling females appeared to decline also but the difference between years is not significant ($Z = 1.49$). Survival of most age classes improved the following winter (1977-1978). We attribute these changes to the effects of the drought during the winter of 1976-1977 (see below).

Recruitment

Both immigrants and squirrels produced locally that enter the breeding population were considered recruits. Although we have not been able to quantify the number of immigrants (since they cannot be distinguished from trap-shy residents), squirrels marked as juveniles that were recaptured the following year represented recruits produced locally. Significantly more juvenile females than males ($\chi^2 = 9.46$) entered the local breeding population (Table 4), further evidence that more juvenile males than females disperse. In contrast, significantly more yearling males than females ($\chi^2 = 7.14$) entered the study population (Table 4). Again, because of their greater mobility, most of these males were likely immigrants. Squirrels of older age groups (2 and + years) and those of uncertain age represented only 18 of 109 (17%) of those recruited on the study sites (Table 4). Many or most of these may have been trap-shy residents rather than immigrants. We conclude that few adult squirrels move to new locations.

We have also examined the possibility that the drought of 1977 affected recruitment. Assuming that all unmarked adults were immigrants, 43 squirrels captured in 1976 were recruits. Ninety seven squirrels were captured on these study sites in 1977, the year of the drought, a

Table 4. Recruitment at study sites, 1976 and 1977. * Significant difference between sexes.

Site	1976					MALES 1977					Both Years				
	J	Y	A	U	Total	J	Y	A	U	Total	J	Y	A	U	Total
1	4	1	0	1	6	4	0	1	0	5	8	1	1	1	11
2	1	1	0	1	3	2	0	0	0	2	3	1	0	1	5
3	3	0	0	0	3	4	4	1	0	9	7	4	1	0	12
4	1	3	1	0	5	4	3	1	0	8	5	6	2	0	13
5	First Year Trapped					2	0	0	0	2	2	0	0	0	2
Total	9*	5	1	2	17	16*	7	3	0	26	25*	12*	4	2	43

Site	1976					FEMALES 1977					Both Years				
	J	Y	A	U	Total	J	Y	A	U	Total	J	Y	A	U	Total
1	4	0	0	0	4	6	0	1	0	7	10	0	1	0	11
2	5	0	1	1	7	4	1	0	0	5	9	1	1	1	12
3	11	0	0	0	11	9	1	0	2	12	20	1	0	2	23
4	2	0	1	1	4	5	0	0	1	6	7	0	1	2	10
5	First Year Trapped					6	0	1	3	10	6	0	1	3	10
Total	22*	0	2	2	26	30*	2	2	6	40	52*	2*	4	8	66

J = Juvenile; Y = Yearling; A = Adult; U = Uncertain age.

significant increase ($X^2 = 20.8$). Squirrels may have increased their home range size during the drought in an effort to secure food. Hence, squirrels living off the study sites would have an increased probability of capture.

Density

There is considerable variation in trap response by ground squirrels depending upon previous encounters with traps. Balph (1968), who studied Uinta ground squirrels (*Spermophilus armatus*) in Utah, found that capture served both as a punishment (confinement) and as a reward (bait). This experience affected catchability during subsequent exposure to traps. Some squirrels became trap-shy and others trap-prone.

Townsend ground squirrels demonstrate similar variation in trap response. Female 352, for example, was captured 3 times in 1975, 32 times in 1976, 25 times in 1977 and 46 times in 1978. Male 663 was captured 5 times in 1976, 36 times in 1977 and 58 times in 1978. Others were trap-shy: male 613 was captured as a juvenile in 1975 and not again until 1977. Female 784 was captured as a juvenile in 1976 and not again until 1978. We believe that there were a few residents which were never captured. Other residents were perhaps captured only once and hence identified as transients. Because of this variation in trap response, we have used density estimators which account for a zero class (animals not caught) (Table 5).

There was no consistent trend in density at study sites during the four years of sampling except at Site 1 where density progressively decreased (Fig. 2). Density decreased at four of the five sites in 1978

Table 5 . Density estimates (N/ha) based on the non-parametric frequency (NF), geometric maximum likelihood (GML) and geometric regression (GR) estimators. -- sample size prevents calculation.

Site	Sex	1975			1976			1977			1978		
		NF	GML	GR	NF	GML	GR	NF	GML	GR	NF	GML	GR
1	male	6.4	7.1	6.0	4.7	4.5	4.2	3.1	3.0	3.0	0.7	0.6	--
	female	12.9	13.1	11.8	7.6	6.7	6.1	3.2	3.0	3.1	3.5	4.3	--
		19.3	20.2	17.8	12.3	11.2	10.3	6.3	6.0	6.1	4.2	4.9	--
2	male	2.7	2.8	2.7	3.6	3.4	3.4	2.2	2.2	2.3	0.7	0.6	--
	female	5.8	5.8	5.1	5.9	5.2	5.1	3.4	3.3	3.4	7.3	7.5	8.3
		8.5	8.6	7.8	9.5	8.6	8.5	5.6	5.5	5.7	8.0	8.1	--
3	male	2.0	2.1	2.0	1.5	1.8	1.6	4.5	4.6	4.4	1.9	2.0	2.0
	female	2.0	2.8	2.2	5.7	5.5	5.4	5.3	5.5	5.4	3.3	2.9	3.3
		4.0	4.9	4.2	7.2	7.3	7.0	9.8	10.1	9.8	5.2	4.9	5.3
4	male	2.5	2.5	2.6	2.4	2.5	2.5	4.2	4.4	3.8	3.0	3.1	2.8
	female	3.3	3.6	3.3	3.5	3.7	3.6	4.0	4.1	4.1	3.9	3.7	3.7
		5.8	6.1	5.9	5.9	6.2	6.1	8.2	8.5	7.9	6.9	6.8	6.5

continued

Table 5 . Continued

Site	Sex	1975			1976			1977			1978		
		NF	GML	GR	NF	GML	GR	NF	GML	GR	NF	GML	GR
5	male	--	--	--	1.2	1.1	1.0	2.5	2.7	2.5	1.0	1.0	--
	female	--	--	--	2.4	2.2	2.3	4.4	4.1	4.1	3.0	3.0	3.1
		--	--	--	3.6	3.3	3.3	6.9	6.8	6.6	4.0	4.0	--
1-5 pooled	male	3.3	3.6	3.2	2.5	2.4	2.4	3.3	3.3	3.3	1.5	1.5	1.4
	female	5.8	6.0	5.3	4.7	4.4	4.3	4.0	4.0	3.6	4.2	4.2	4.1
		9.1	9.6	8.5	7.2	6.8	6.7	7.3	7.3	6.9	5.7	5.6	5.6

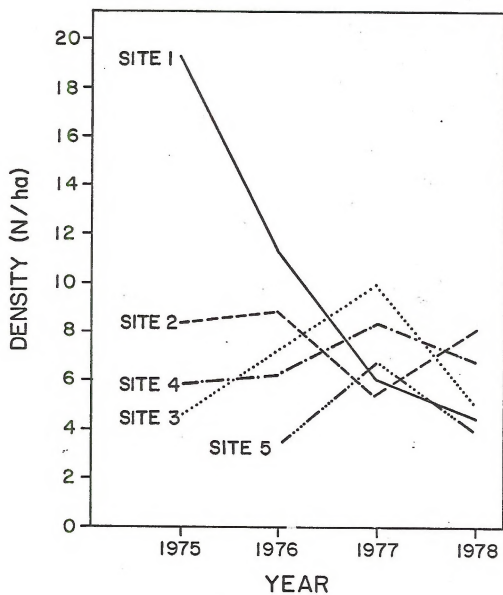


Fig. 2. Mean density estimates (N/ha) on intensive study sites.

as a result of a suspension in reproduction during the drought the previous year (see below). The density of females at trapping sites was usually greater than that of males because (1) residents made up a larger proportion of the female population (Table 2), (2) survival of juvenile females was greater (Table 3), and, (3) more juvenile females were recruited into the resident population (Table 4).

Density in Relation to Habitat Types

Although Townsend ground squirrels are widely distributed north of the Snake River in the BPSA, the species occurs only in scattered colonies near Fossil Butte south of the river. Squirrels are absent from the canyon.

There is a considerable variation in density which can be related to the cover vegetation (Table 6). At sites with perennial and annual grasses and big sage coverage less than 20% (Big Sage 1), ground squirrel density averaged 3/ha. At those sites where big sage coverage was greater than 20% and only annual grasses were present (Big Sage 2), squirrel density was reduced to 1.7/ha, while at similar sites with few annual grasses (Big Sage 3), the density was 1.3/ha. Within mixed big sage-winterfat stands, density was highest at sites where the sage coverage was less than 10% (Big Sage-Winterfat 1). Shadscale sites supported few squirrels.

Of the three major habitat types, big sage, winterfat and shadscale, squirrel densities were highest in stands where winterfat was the dominant or codominant species. Allred(1973) also found that Townsend ground squirrels were more abundant in winterfat than in any other habitat type in eastern Idaho.

Table 6. Density indices on ground squirrel hole-count transects within representative habitat types on the BPSA.

Habitat Type	Number of Transects	Mean $\pm$ SE	95% CI	Estimated Density (N/ha)
Big Sage 1	61	18.3 $\pm$ 0.74	15.4 - 21.2	3.0
Big Sage 2	44	10.5 $\pm$ 1.38	7.7 - 13.3	1.7
Big Sage 3	36	8.1 $\pm$ 1.44	5.1 - 11.0	1.3
Winterfat	11	25.9 $\pm$ 5.08	14.6 - 37.2	4.2
Big Sage-Winterfat 1	27	32.4 $\pm$ 2.97	26.3 - 38.5	5.3
Big Sage-Winterfat 2	11	19.4 $\pm$ 3.86	10.8 - 28.0	3.1
Shadscale 1	18	10.9 $\pm$ 2.22	6.2 - 15.6	0.3
Shadscale 2	16	16.7 $\pm$ 1.94	12.6 - 20.8	0.7
Shadscale-Winterfat	43	16.1 $\pm$ 1.35	13.4 - 18.8	0.6
Grass 1	14	26.1 $\pm$ 4.66	16.1 - 36.2	4.4
Grass 2	48	11.7 $\pm$ 1.40	8.9 - 14.5	1.9
Crested Wheatgrass	9	3.4 $\pm$ 2.11	-1.1 - 8.7	0.1
Shadscale-Big Sage	10	13.8 $\pm$ 3.51	5.8 - 21.7	0.3
Alfalfa	4	110.0 $\pm$ 5.20	99.6 - 120.4 *	-- *

* Conversion factor to estimate density in alfalfa not available.

At sites lacking a shrub cover (Grass 1 and 2; Table 6), squirrel density was higher when grass coverage exceeded 20% (Grass 1 sites) than those where grass coverage was less than 20% (Grass 2 sites).

Density in Relation to Land Use

Light to moderate grazing pressure apparently favors an increase in squirrel density on the BPSA. Density at Site 1 which was used as a bedding site during winter grazing by sheep was three to four times that at Site 2 which was less heavily utilized (Table 5). This difference was reversed by 1978 however, due to the effects of the drought and the almost total lack of vegetation at Site 1.

Squirrels also occurred at high densities in the Sand Creek watershed (a Grass 1 habitat) where an earlier range fire destroyed the sagebrush cover and enhanced grass production. Ground squirrel density progressively increased at Site 3 (Table 5) where a range fire destroyed the shrub cover in 1974. Density at Site 3 surpassed that of an adjoining unburned area (Site 4) by 1976. Squirrel numbers at both sites declined after the drought (Table 5).

We conclude that light to moderate grazing and range fires in sage and winterfat habitat types on the BPSA favors an increase in ground squirrel density if a healthy stand of grass is maintained following the perturbation.

Ground squirrels did not occur in cropland except in alfalfa fields where hole counts indicated that their density was likely the highest encountered (Table 6). Farmers in the area use poisons to control squirrels within alfalfa fields, not only to decrease squirrel numbers but to discourage badger burrowing and subsequent damage to farm machinery.

Food Habits

Grass leaves and stems comprised a large part of the diet of ground squirrels at all locations where sampling occurred (Table 7). We assume that cheatgrass provided most of this forage since it is the most common grass on the BPSA. Since cheatgrass is a winter annual, it provides green forage early in the spring. Grass seeds were utilized when they became available in late May. The leaves of winterfat, shadscale and bud sage were locally important food items, depending on their availability. The principal forb seed taken was that of a mustard *Descurainia pinnata*. The few insects taken were primarily beetles and lepidopterous larvae. The kinds of food eaten by juveniles was similar to that taken by older age groups. Squirrels were seen feeding on road-killed individuals of their own kind and on the carcass of a gopher snake (*Pituophis melanoleucus*).

We have no specific information on the effects of the drought on diet since we did not systematically sample at the same locations in consecutive years. The results reported in Table 7 represent a compilation of samples taken at various locations within habitat types over three years.

Reproduction

Adult males emerged from torpor with scrotal testes, usually in late January. Adult females usually emerged 1-2 weeks later and yearling females shortly thereafter. Females were bred soon after emergence. Copulation apparently took place below ground since it was not observed during this study. In most years, yearling males emerged after breeding

Table 7. Estimated volume (%) of food items in 174 stomachs. T = trace (less than 1 %).
Samples are mostly adult squirrels (Feb-Apr) and juveniles (May-Jul).

Habitat Type/Month(s)	No. of Stomachs	Grass		Leaves			Forb		Insect
		Leaf	Seed	Shadscale	Winterfat	Bud sage	Leaf	Seed	
Grass (Apr)	6	46					54		T
(Sand Creek) (May)	3	80	19				1		T
(Jun)	9	29	41				8	22	
(Jul)	9	1	13				26	59	T
Winterfat (Feb-Mar)	7	92			T		6		1
(Apr-May)	11	15	7	T	60		15		3
Big Sage (Feb-Mar)	9	92	T				7	T	1
(Apr)	8	74					19		7
(May)	9	88			T		8		4
(Jun)	11	36	48				5		10
(Jul)	4	19	25				56		T
Sage-Winterfat (Feb-Mar)	18	93	T		T		6		T
(Apr)	12	65		1	18		11		5
(May)	13	45	7		38		9	T	1
(Jun)	3	23	23		17		33		3
Shadscale (Mar)	10	34		14	4	28	21		T
(Fossil Butte) (Apr)	12	25		3	20	29	20		3
(May)	11	38		2	7	T	46	6	1
(Jun)	9	50	21	2	1	9	15	T	2

activity had declined. As in the Uinta ground squirrel (Slade and Balph 1974), yearling males were not reproductively active.

The gestation period of the Townsend ground squirrel is about 24 days (Svihla 1939). Since there was no significant difference between embryo and placental scars counts ($t = -1.57, -.66$ and -1.21 for 1975, 1976 and 1978 respectively), these were combined in calculating mean litter size (Table 8). The litter size in 1978 was significantly larger than in previous years. Since we did not collect known-age squirrels, we were unable to determine if the litter size of yearlings and older age groups differ. Uinta ground squirrel yearlings produce smaller litters (Slade and Balph 1974), but there is no difference in litter size among age groups of the Richardson ground squirrel (Sheppard 1972).

The mean litter size of the study population *Spermophilus townsendi idahoensis* was significantly smaller ($t = -2.47$) than that of the Great Basin subspecies *S. t. mollis* found south of the Snake River (Table 8). Alcorn (1940) found a similar litter size for the latter subspecies in western Nevada.

An average of 55% of the yearling females and 100% of the older age females produced litters before the drought (Table 9). There was no litter production on the study area during the drought (see below). All adult females were gravid the year following the drought (1978), at a time when there was no yearling cohort present on the study sites (Table 9). Slade and Balph (1974) also observed higher pregnancy rates in older age groups of the Uinta ground squirrel.

Using indirect methods, Michener (1973) estimated that juvenile

Table 8. Litter size (mean $\pm$ standard error) based on embryo and placental scar counts.

Spermophilus townsendi idahoensis

1975	7.15 $\pm$ 0.2	(N = 41)
1976	7.57 $\pm$ 0.3	(N = 37)
1977	0	(N = 36)
1978	9.21 $\pm$ 0.3	(N = 34)

Spermophilus townsendi mollis

1976	9.29 $\pm$ 0.6	(N = 17)
1977	8.77 $\pm$ 0.5	(N = 18)

Table 9. Reproductive status of resident females. Percent in parentheses.

Year	Site	Yearling		Adult	
		Non-gravid	Gravid	Non-gravid	Gravid
1975	1	10	10	0	16
	2	4	2	0	2
	3	2	4	0	4
	4	<u>1</u>	<u>1</u>	<u>0</u>	<u>3</u>
Total		17	17 (50)	0	25 (100)
1976	1	2	6	0	9
	2	3	2	0	9
	3	1	3	0	8
	4	1	3	0	3
	5	<u>3</u>	<u>2</u>	<u>0</u>	<u>4</u>
Total		10	16 (62)	0	33 (100)
1977	1	9	0	2	0
	2	7	0	5	0
	3	7	0	6	0
	4	10	0	6	0
	5	<u>5</u>	<u>0</u>	<u>9</u>	<u>0</u>
Total		38	0	28	0
1978	1			0	4
	2		No	0	8
	3		Yearling	0	13
	4		Cohort	0	14
	5			<u>0</u>	<u>13</u>
Total				0	52 (100)
Grand Total		65	33 (34)	28	110 (80)

Richardson ground squirrels remain underground 30 days after birth. We have no precise measure of the length of the nestling period (birth to emergence) but it is likely three to four weeks. Juveniles were first seen above ground on 7 April 1975, 26 March 1976 and 29 March 1978. Weaning occurred shortly after emergence. Mean litter count of emerging squirrels was 5.3 ($N = 7$) in 1976. Since mean litter size was 7.5 that year, there was a 30% mortality between birth and emergence.

The sex ratio of juveniles favored males (1.24 : 1; $N = 493$) while that of yearlings (0.46 : 1; $N = 73$) and adults (0.61 : 1; $N = 140$) favored females.

Drought Effects on Reproduction

During the 1977 drought, squirrel reproduction was completely suspended on sites supporting native vegetation within the BPSA north of the Snake River. Adult males emerged from torpor with scrotal testes. We assume that females did not come into breeding condition and that no copulation or ovulation occurred. We found no implanted embryos in 36 females collected during the breeding season (Table 8) nor was there any evidence of breeding by 38 yearling or 28 adult females live-trapped on the study sites at that time (Table 9).

We can relate changes in pregnancy rate to the amount of available green forage, particularly cheatgrass, the principal dietary component, and, ultimately, to the fall (September-December) precipitation the previous year. Fall precipitation at Kuna and Swan Falls weather stations was 4.7 and 2.2 cm respectively below the long-term average for those months in 1976, the beginning of the drought (Table 10). The mean coverage of grasses, principally cheatgrass, declined from 25% in 1975

Table 10. Rainfall (cm) at two weather stations within the Birds of Prey Study Area.

Station/Time Period	1974	1975	1976	1977
Swan Falls Power House				
September-December	6.5	6.7	3.7	7.8
Annual *	14.9	21.1	16.9	19.6
Kuna				
September-December	6.9	7.8	3.8	12.2
Annual **	17.7	28.9	24.7	25.2

* Long-term average 19.3 cm

** Long-term average 25.1 cm

and 1976 to less than 1% in 1977 (Table 11).

Cheatgrass requires about 5 cm of rainfall during the fall months for proper germination (Hull and Pechanec 1947). Heavy seedling winterkill may also occur if there is little precipitation (snow-cover) and high winds (Klemmedson and Smith 1964). The reduced coverage of grasses in 1978, despite the heavy precipitation the previous fall, probably resulted from a lack of seed sources. There was a heavy cover of Russian thistle (*Salsola kali*) and tumble mustard (*Sisymbrium altissimum*) on certain sites in 1978 (Table 1). These species are efficient colonizers of bare sites since the wind distributes the dried seed-laden plants for considerable distances.

The close relationship between green forage and reproduction by Townsend ground squirrels is further substantiated by the occurrence of litter production by females which had access to irrigated alfalfa crops during the drought. Certain females of the *mollis* subspecies living in old fields south of the Snake River also produced litters in 1977 (Table 8), however juvenile survivorship appeared to be low.

The relationship of rodent reproduction to green vegetation and ultimately to rainfall in desert and semidesert areas has been pointed out by Fitch (1948:556), Reynolds (1958) and recently by Beatley (1969, 1976). Reynolds and Turkowski (1972) found that dry winters delayed the breeding season and reduced the litter size of the round-tailed ground squirrel (*Spermophilus tereticaudus*) in Arizona. After 47 cm of rainfall the previous year, a population of Merriam kangaroo rats (*Dipodomys merriami*) reproduced normally one spring near Silver Bell,

Table 11. Mean grass coverage (%) on study sites.

Site	1975	1976	1977	1978
1	64.8	68.0	<1	16.1
2	25.0	11.4	2.0	8.1
3	3.4	3.4	<1	<1
4	9.8	15.0	<1	6.9
5	--	29.1	<1	11.4
Mean	25.75	25.4	<1	6.9

Arizona, while another population near Phoenix, a site receiving only 17 cm of rainfall during the same period, failed to reproduce (Van de Graaff and Balda 1972). There was a strong positive relationship between the proportion of green vegetation in the diet of both Merriam kangaroo rats and Arizona pocket mice (*Perognathus amplus*) and breeding condition in these species one month later (Reichman and Van de Graaff 1975).

Certain investigators favor the hypothesis that the green forage serves as a source of water during the breeding season (Beatley 1969, 1976; Bradley and Mauer 1971). The recent observation that Merriam kangaroo rats utilize the greatest amount of green forage during lactation (Soholt 1977) seems to support this hypothesis.

An alternative hypothesis proposes that substances in the developing plants bring rodents into breeding condition (Chew and Butterworth 1964). Negus and Berger (1977) induced breeding in a wild population of montane voles (*Microtus montanus*) during the winter months by distributing freshly germinated wheat seedlings in their runways. A nearby control population remained in typical winter non-breeding condition. The estrogenic properties of many plants are well established (Labov 1976).

Population Regulation

Since population regulation is the action of those processes which tend to restore a steady-state density (Slade and Balph 1974), the resumption of breeding in 1978 following the drought provides us with an opportunity to identify those factors which operate to regulate the

study population.

We have used measured values in calculating parameters describing population stability (Table 12) as follows: survival of juvenile females .28; survival of older age classes .36; litter size at emergence 5.3; sex ratio favoring males 1.24 : 1; and, a pregnancy rate of .55 for yearlings and 1.0 for adult females. These calculations ignore the loss of complete litters before emergence but we believe that this does not seriously affect our conclusions. We know of the loss of at least two litters on Site 1 to badgers prior to emergence in 1975.

Since the calculated rate of population change (r) was negative (Table 12), the study population was declining, a conclusion confirmed by our density estimates (Table 5). The finite rate of population change was .827; that is, for every 1,000 individuals in the population, only 827 will be present one year later. Stability ($r = 0$) or a population increase ($r > 0$) could be produced by (1) increased survival, (2) improved immigration, (3) an altered sex ratio in favor of females, (4) an increase in litter size, or, (5) an increase in the pregnancy rate of yearlings. We have excluded the production of multiple litters as a means of increasing numbers because of climatic factors.

The overwinter survival, that is, the proportion of marked squirrels recovered the following year, was .32 in 1977-78 (Table 3), a value significantly higher ($Z = 3.29$) than that in the drought year. Slade and Balph (1974) found improved survival of all age classes of Uinta ground squirrels following the artificial reduction of their study population.

Table 12 . Life table population parameters.

X	l_x	m_x	$l_x m_x$	$x(l_x m_x)$	e^{-rx}	$e^{-rx} l_x m_x$
0	1.000	0	0	0	1	0
1	.280	1.30	.364	.364	1.21	.440
2	.101	2.37	.239	.479	1.46	.349
3	.036	2.37	.085	.256	1.77	.150
4	.013	2.37	.031	.123	2.14	.066

X age class (years)

l_x proportion alive at beginning of time interval

m_x age-specific reproductive rate (number of females emerging for each female)

e base of natural logs

R_0 net reproductive rate = $\sum l_x m_x = 0.719$

T_c approximate mean generation time = $\sum x(l_x m_x) / \sum l_x m_x = 1.7$ years

r instantaneous rate of population change = $\ln(R_0) / T_c = -.194$

or realized rate of population change calculated by iterative solution of

$1 = \sum e^{-rx} l_x m_x$, in this case $-.19$

e^r finite rate of population change = .827

We have already shown (Table 4) that recruitment was significantly increased during the drought. We assume that squirrels increased the size of their home range in their search for food and ultimately the use of study sites where food was available. While a portion of these unmarked squirrels appearing for the first time could have been trap-shy residents, we believe that these cannot account for all of the increase. Hence the immigration rate increased on study sites during the drought, perhaps in response to the availability of a food source.

Since we observed no change in sex ratio before or after the drought, we exclude it as a mechanism in population regulation.

There was a significant increase in litter size of the study population following the drought (Table 8). Slade and Balph (1974) found no change in the litter size of Uinta ground squirrels following a reduction of their study population. They observed an increase in the pregnancy rate of yearling females, a factor we have not yet investigated since the first yearlings will not appear on our study area until the spring of 1979.

We conclude that increases in survival, immigration and litter size were the chief factors regulating the study population following a reduction in density. A change in the pregnancy rate of yearling females may also occur.

Mortality Factors

Weather

Differential mortality during the first winter of torpor may adjust the sex ratio from one favoring juvenile males to one favoring

yearling females. Slade and Balph (1974) found that the mean weight of surviving juveniles at submergence was significantly greater than that of juveniles which died during the winter. An analysis of overwinter survival in relation to mean weight at submergence showed no significant relationship in our study population however (Table 13).

Other factors may adjust the sex ratio in favor of females. Juvenile males may be left with inadequate hibernation sites because of their delay in entering torpor (Michener and Michener 1977). The same authors suggest that cannibalism by burrow mates might occur during bouts of arousal. Carl (1971) and Sheppard and Swanson (1976) have reported that the selection of inadequate hibernation sites was the principal cause of overwinter mortality in Arctic (*Spermophilus undulatus*) and Richardson ground squirrels respectively.

Predation

Several studies have shown that reptilian, avian and mammalian predators take a moderate to heavy toll of ground squirrels. Beechey ground squirrels (*Spermophilus beecheyi*) were the major prey of the western rattlesnake on the San Joaquin Experimental Range near Madera, California, comprising 69% of the biomass ingested (Fitch 1948). Snake predation was particularly heavy on juveniles. Using scat analysis and palpation, Diller (Pers. comm.) found that Townsend ground squirrels comprised 32 of 53 (60%) of the prey taken by western rattlesnakes and 4 of 36 (11%) of the prey taken by gopher snakes on the BPSA.

With respect to avian predation, Luttich et al. (1970) found that red-tailed hawks took a significant proportion of a Richardson ground

Table 13. Overwinter survival in relation to body weight (mean $\pm$ standard error) at entrance into torpor. Sample size in parentheses.

Age Class/ Sex	Winter	Mean Weight (g)		Significance
		Surviving	Disappearing	
Juvenile males	1975-76	191 $\pm$ 20 (3)	194 $\pm$ 6 (22)	NS
	1976-77	192 $\pm$ 7 (9)	187 $\pm$ 3 (42)	NS
Yearling and older males	1975-76	306 $\pm$ 13 (6)	274 $\pm$ 20 (4)	NS
	1976-77	252 $\pm$ 23 (4)	255 $\pm$ 17 (8)	NS
	1977-78	247 $\pm$ 10(10)	240 $\pm$ 6 (28)	NS
Juveniles females	1975-76	168 $\pm$ 9 (12)	156 $\pm$ 11 (4)	NS*
	1976-77	163 $\pm$ 6 (18)	160 $\pm$ 3 (35)	NS
Yearling and older females	1975-76	224 $\pm$ 14 (5)	203 $\pm$ 13 (4)	NS
	1976-77	213 $\pm$ 6 (3)	194 $\pm$ 13 (5)	NS
	1977-78	201 $\pm$ 5 (16)	191 $\pm$ 5 (18)	NS

squirrel population in Alberta, especially adult males. Fitch et al. (1946) found that the Beechey ground squirrel was the principal prey of red-tailed hawks nesting on the San Joaquin Experimental Range, California. They estimated that ground squirrels comprised 50% of the annual diet and that a pair of red-tailed hawks took 144 squirrels annually.

Townsend ground squirrels are the principal prey of prairie falcons nesting on the BPSA (Ogden and Hornocker 1977). Although the proportion of squirrels in the diet declined in 1977, the species remained the principal prey item taken by prairie falcons during the drought (Peterson et al. 1977). Ground squirrels are also important prey for red-tailed hawks, ferruginous hawks (*Buteo regalis*) and ravens (*Corvus corax*) on the BPSA (Kochert et al. 1976).

Badgers are also important ground squirrel predators. Thirty eight of 92 (41%) of the predator scats (chiefly badger) in a Saskatchewan study contained the remains of Richardson ground squirrels (Sheppard and Swanson 1976). The badgers did not appear to be selective in taking squirrels since age groups of the remains found in scats were similar to those found in the trapable population.

The remains of Townsend ground squirrels were found in 300 of 427 (70%) of the badger scats collected on the BPSA. Ground squirrels remained an important prey item in the badger diet throughout the year (Messick, Pers. comm.). Counts of badger hunting attempts on our study sites indicated that most effort was expended in digging out squirrels during the period July through October (Table 14). There is a strong

Table 14. Badger hunting attempts on intensive study sites, 1975-78. -- not surveyed.

Month Year	Site 1				Site 2				Site 3				Site 4				Site 5		
	75	76	77	78	75	76	77	78	75	76	77	78	75	76	77	78	76	77	78
Jan	--	0	0	0	--	0	0	0	--	2	--	0	--	0	0	0	--	0	0
Feb	--	0	0	0	--	0	0	0	--	0	2	0	--	0	8	0	0	0	0
Mar	4	0	1	0	1	2	0	1	0	0	4	2	0	0	0	1	0	0	0
Apr	5	4	0	0	2	3	0	0	2	5	10	3	3	4	3	0	0	3	0
May	11	15	17	2	4	4	4	0	2	6	28	5	0	1	6	5	0	7	0
Jun	5	11	17	8	2	2	3	0	10	2	18	0	9	3	5	3	2	8	0
Jul	32	91	3	0	6	22	1	0	12	7	6	0	5	3	3	0	4	1	0
Aug	15	197	--	--	3	17	--	--	16	21	--	--	6	1	--	--	5	--	--
Sep	3	57	--	--	5	5	--	--	15	30	--	--	2	2	--	--	28	--	--
Oct	18	18	--	--	5	2	--	--	5	25	--	--	10	4	--	--	15	--	--
Nov	7	3	--	--	4	1	--	--	7	11	--	--	0	4	--	--	5	--	--
Dec	1	1	--	--	5	0	--	--	0	3	--	--	1	1	--	--	2	--	--
Total	101	398	38	10	37	58	8	1	69	102	68	10	36	23	25	9	61	19	0

relationship between badger hole counts and squirrel density both on our study sites and elsewhere on the BPSA (Table 15).

There has been little effort in estimating the totality of predation on a ground squirrel population. Fitch (1948) estimate that western rattlesnakes, red-tailed hawks, gopher snakes and coyotes (*Canis latrans*) removed more than one-half of the annual increase of Beechey ground squirrels in a California study.

Disease

The continuing presence of the bubonic plague organism (*Yersinia pestis*) in the ground squirrel population on the BPSA has been confirmed by the recovery of eight plague-positive squirrels and by the occurrence of elevated plague antibody titers in the badger population (Messick et al. In press). Plague has decimated rodent populations over wide areas of the western United States in the past and the possibility exists that an epizootic could eliminate much of the squirrel population on the BPSA. There was a slow recovery of the Townsend ground squirrel populations apparently decimated by plague in Utah (Hansen 1956), evidence that the occurrence of an epizootic on the BPSA might have a prolonged effect on predator-prey relationships at that location.

Table 15. Correlation coefficients (r) of mean badger hole counts with respect to ground squirrel hole counts on transects. * $P < .05$

Habitat Type	N	r $\pm$ std. error	Significance
Big sage 1	60	0.79 $\pm$.001	*
Big sage 2	44	0.76 $\pm$.001	*
Big sage 3	36	0.88 $\pm$.001	*
Winterfat	11	0.94 $\pm$.001	*
Big sage-winterfat 1	27	0.70 $\pm$.001	*
Big sage-winterfat 2	11	0.91 $\pm$.001	*
Shadscale 1	18	0.49 $\pm$.018	*
Shadscale 2	16	0.59 $\pm$.008	*
Shadscale-winterfat	43	0.83 $\pm$.001	*
Grass 1	14	0.77 $\pm$.001	*
Grass 2	25	0.58 $\pm$.001	*
Crested wheatgrass	8	0.94 $\pm$.001	*
Shadscale- big sage	10	0.49 $\pm$.073	NS

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Appendix A . Location of ground squirrel hole count transects.

Township	Range	Quarter Section	Section(s)
1 N	1 W	NW	11, 12, 26
		NE	22
		SE	3, 4, 9, 14, 20, 21, 23, 28, 32, 33, 34
		SW	1, 9, 16, 20, 25, 29, 36
1 N	1 E	NE	8, 24, 31
		SE	16
		SW	17, 28, 30, 31
1 N	2 E	NE	34
		SE	20, 29
		SW	33, 36
1 S	1 W	NW	12, 13, 15, 21, 28
		NE	4, 15, 16, 23, 24, 25
		SE	4, 5, 10, 22
		SW	2, 8, 9, 13, 17, 23, 25
1 S	1 E	NW	1, 3, 7, 12, 14, 15, 17, 18, 29, 33
		NE	5, 6, 9, 19, 21, 31, 32
		SE	8, 26, 27, 31, 35
		SW	2, 3, 25, 30, 31
1 S	2 E	NW	6, 7, 11, 32
		NE	3, 9, 19, 26, 29
		SE	12, 14, 15, 24
		SW	1, 16, 27
1 S	3 E	NE	31
		SE	26, 29, 34
		SW	17, 20, 21
2 S	1 E	NW	6, 8
		NE	1, 3, 5, 7, 10, 11, 21, 23, 29, 34, 35
		SE	5, 8, 13, 17, 22, 33, 34
		SW	3, 9, 15, 17, 21
2 S	2 E	NW	3, 8, 19, 30, 31
		NE	2, 27
		SW	7, 15, 33
2 S	3 E	NW	4, 5
2 S	4 E	NW	6, 17, 20, 29
		NE	27
		SE	5, 27, 34, 36
		SW	7, 8, 32

Appendix A , Continued

Township	Range	Quarter Section	Section(s)
3 S	2 W	SE	24
3 S	1 W	NW	20, 27
		NE	29
		SE	28, 29
		SW	18, 26
3 S	1 E	NW	1, 11, 23
		NE	4, 9, 14, 24
		SE	1
		SW	4, 11, 12
3 S	2 E	NW	6, 8, 10, 13, 15, 16, 18, 20, 32, 35, 36
		NE	22
		SE	3, 4, 18, 20, 21, 36
		SW	27, 33, 34
3 S	3 E	NW	19, 34, 35
		NE	32
		SE	25, 30
		SW	36
3 S	4 E	NW	8, 20, 34
		NE	27, 36
		SE	10, 15
3 S	5 E	NW	9, 13, 15, 16, 29, 30
		NE	4, 10, 11, 20, 25
4 S	2 E	NW	24
		NE	3, 13
		SE	1, 2, 12
		SW	2
4 S	3 E	NW	6, 9, 11
		NE	15, 16, 21, 25, 26, 35
		SE	7, 8, 18
		SW	5, 12, 14, 23, 24, 25
4 S	4 E	NW	15, 21, 22, 31, 34
		NE	3, 17, 23
		SE	25
		SW	9, 29, 36
4 S	5 E	NW	10
		NE	2, 18
		SE	13
		SW	12, 15, 31

Appendix A . Continued

Township	Range	Quarter Section	Section(s)
4 S	6 E	NW	7, 8, 14, 30
		NE	9, 36
		SE	15, 28, 33, 34
		SW	9, 22, 32
4 S	7 E	NW	10, 26
		NE	19, 22, 34
		SE	10, 13, 21, 29, 36
		SW	9, 10, 25
4 S	8 E	NW	19
		NE	17, 29, 32
		SE	19
		SW	7
5 S	5 E	NW	1, 2, 9, 12, 14, 16, 17
		NE	5, 13, 23, 24
		SW	11
5 S	6 E	NE	28, 29
		SE	18, 19, 29
		SW	4
5 S	7 E	NW	7, 17
		NE	14, 16, 24
		SW	2, 4, 23
5 S	8 E	NE	7
		SW	6, 8, 30

Appendix B. Number of squirrels caught on study sites. --Not trapped.

Site	Juvenile Males					Yearling Males				
	1975	1976	1977	1978	Total	1975	1976	1977	1978	Total
1	31	54	0	8	93	17	9	8	0	34
2	12	25	0	9	46	5	8	4	0	17
3	17	34	0	9	60	4	3	14	0	21
4	3	18	0	16	37	4	3	10	0	17
5	--	24	0	12	36	--	2	4	0	6
6	--	11	0	--	11	--	0	1	--	1
Total	63	166	0	54	283	30	25	41	0	96

Site	Adult Males					Uncertain Age Males				
	1975	1976	1977	1978	Total	1975	1976	1977	1978	Total
1	8	8	6	3	25	3	1	0	0	4
2	5	6	5	3	19	5	2	2	0	9
3	4	6	4	9	23	1	0	3	0	4
4	7	6	9	13	35	0	2	1	0	3
5	--	3	6	5	14	--	0	1	0	1
6	--	1	0	--	1	--	0	0	--	0
Total	24	30	30	33	117	9	5	7	0	21

Site	All Males				
	1975	1976	1977	1978	Total
1	59	72	14	11	156
2	27	41	11	12	91
3	26	43	21	18	108
4	14	29	20	29	92
5	--	29	11	17	57
6	--	12	1	--	13
Total	126	226	78	87	517

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Appendix B. Continued.

Site	Juvenile Females					Yearling Females				
	1975	1976	1977	1978	Total	1975	1976	1977	1978	Total
1	9	47	0	6	62	25	8	9	0	42
2	7	25	0	13	45	11	7	7	0	25
3	24	29	0	4	57	4	15	11	0	30
4	3	14	0	15	32	7	4	7	0	15
5	--	23	0	4	27	--	5	5	0	10
6	--	6	0	--	6	--	0	1	--	1
Total	43	144	0	42	229	47	39	40	0	126

Site	Adult Females					Uncertain Age Females				
	1975	1976	1977	1978	Total	1975	1976	1977	1978	Total
1	16	14	2	3	35	3	3	1	0	7
2	3	8	5	8	24	5	6	1	0	12
3	4	4	5	13	26	0	3	4	0	7
4	5	8	7	15	35	0	2	3	0	5
5	--	4	8	13	25	--	1	3	0	4
6	--	0	0	--	0	--	0	0	--	0
Total	28	38	27	52	145	8	15	12	0	35

Site	All Females					All Squirrels				
	1975	1976	1977	1978	Total	1975	1976	1977	1978	Total
1	53	72	12	9	146	112	144	26	20	302
2	26	46	13	21	106	53	87	24	33	197
3	32	52	20	17	121	58	95	41	35	229
4	15	28	17	30	90	29	57	37	59	182
5	--	33	16	17	66	--	62	27	34	123
6	--	6	1	--	7	--	18	2	--	20
Total	126	237	79	94	536	252	463	157	181	1053